CERTAIN STATISTICAL CHARACTERISTICS OF SIGNALS THAT ARE PARTIALLY REFLECTED FROM THE D-REGION OF THE IONOSPHERE

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Experiments performed on an installation for investigating the D-region of the ionosphere by the method of partial reflections have shown that the amplitudes of the signals are distributed according to the Rayleigh law, and that the characteristic time \( \tau_0 \) of the amplitude fluctuations depends on the dimensions \( \theta_0 \) of the antenna radiation patterns. An interpretation is presented of the obtained results using the model of "frozen" inhomogeneities that move in the horizontal direction with a velocity \( v \).

In order to determine the profiles \( N(h) \) of the electron concentration in the D-region of the ionosphere by the method of partial reflections of radio waves it is important to know the properties of the inhomogeneities which cause back-scattering or partial reflection of radio waves. The study of the inhomogeneities of the structure of the lower ionosphere is likewise of independent scientific interest. In the present paper we present certain experimental data on the statistical properties of partial reflections of radio waves, and their possible interpretation on the basis of the model of "frozen" inhomogeneities that move in a horizontal direction.

The Equipment and Observation Procedure. An installation for studying the D-region of the ionosphere by the method of partial reflection, which is situated near the city of Gor'kii, was used in the experiments. The transmitter of the installation operated at a frequency of 5.75 MHz with a pulse power of the order of 750 kW. The length of the investigated pulses was equal to 50 \( \mu \)sec, while their repetition frequency was 50 Hz. The transmitting antenna (four half-wave dipoles) had a calculated radiation pattern of about 56° x 56° at the half-power level and was linearly polarized. The main receiving antenna (I) consisted of 36 pairs of crossed dipoles. The dimensions of its radiation pattern at the half-power level are equal to \( \sim 12° \times 12° \). Using this antenna, it was possible to receive signals having both linear and both circular polarizations.*

In the described experiments the signals in the majority of cases were also simultaneously received by an additional antenna having a very wide radiation pattern. For this purpose a rhombic antenna (II) of the type used at atmospheric research stations, and a pair of crossed dipoles (antenna III) allowing the reception of a radio wave with circular polarization were used. During the process of the observations the signals from the two different antennas were applied alternately with a switching frequency of 25 Hz to the input of a common receiving-recording device. After detection the signal amplitudes were reproduced on the screen of a two-beam oscilloscope with a common height sweep and were recorded on photographic film. The exposure time of each frame was either 0.1 or 0.5 sec. In a number of cases continuous variations of the amplitudes of the signals from specified altitudes were recorded on a moving photographic film by means of strobing. Sessions of observations lasted approximately 5 to 6 min.

The experiments were carried out on separate days in the spring of 1970 and were partially repeated in March 1971. Typical recordings obtained at the hours close to midday were subjected to detailed

*Signals with circular polarizations correspond very closely at the latitude of the city of Gor'kii to the polarizations of the ordinary and extraordinary components for vertical propagation.
processing. Processing consisted in finding the distribution functions of the amplitudes $A$ of the signals at various fixed altitudes $h_0$, and in determining the autocorrelation functions of the amplitudes $\rho_A(h_0, \tau)$.

The Results of the Observations. Figure 1 displays the experimental distribution functions $W_1[A_1(h_0)]$ of signals having linear (the triangles and squares) and both circular polarization (the circles), which were obtained by means of antennas I and II at several altitudes $h_0$. The solid curve depicts the calculated amplitude probability distribution function according to the normalized Rayleigh law

$$W_1 = A_1 \exp\left(-\frac{A_1^2}{2}\right).$$

where $W_1 = W_0, A_1 = A/\sigma, 2\sigma^2 = \bar{A}^2$ (the bar above a quantity denotes statistical time averaging). As is evident from Fig. 1, the experimental functions $W_1$ can be described fully satisfactorily by the Rayleigh law.

Figure 2 displays the autocorrelation functions $\rho_A(h_0, \tau)$ which have been calculated according to the oscillograms of $A(h_0, t)$ at altitudes of 73 km (curves 1 and 2) and 78 km (curves 3 and 4). Under these conditions curves 1 and 3 were obtained by means of the "narrow" radiation pattern of the antenna (antenna I), while curves 2 and 4 were obtained by means of the "wide" pattern (antenna II). The polarization of the antennas was linear in this case. Figure 3 displays analogous curves $\rho_A(h_0, \tau)$ for the ordinary component (antennas I and III; altitude $h_0 = 80$ km). Attention should be focused on the fact that for all pairs of curves a slower decrease of $\rho_A$ corresponded to a narrower radiation pattern of the antenna.

Table 1 displays the values of the time correlation radii $\tau_0$ determined at the $\rho_A(\tau_0) = 1/e = 0.37$ level. As is evident from Table 1, the values of $\tau_0$ (II, III) obtained with antennas II and III turned out to be approximately twice as small as the values of $\tau_0$ (I) obtained by means of antenna I.